<u>Amendments to the Drawings:</u>

The attached sheets of drawings include changes to FIG. 4 which is now renumbered as FIG 4A, FIG 4B,and FIG.4C for portions on spate sheets. These sheets replace the original sheets including FIG. 4.

In FIG. 4, the following steps have been amended:

<u>Step 16:</u>

~~If a feasible solution to the MILP model is available, update~~ <u>Update</u> the best known integer feasible solution in the B&C algorithm

<u>Step 20:</u>

Is the solutions found ~~by the B&C algorithm~~ optimal <u>for the MILP model</u>?

<u>Step 21:</u>

Stop the B&C algorithm~~. Go to rostering~~ <u>and report schedules</u>

<u>Step 22:</u>

Is the solution ~~feasible and~~ violating integrality constraints?

<u>Step 23:</u>

Obtain the objective value for the best integer solution stored in the B&C algorithm~~, and update the one stored by the RA algorithm~~

<u>Step 24:</u>

Obtain the values of the decision variables in the non-integer solution to current sub-problem <u>and round them down</u>

<u>Step 26:</u>

Does the rounded solution have correct number of ~~days-off and~~ daily shifts?

Step 27:

Schedule additional ~~days-off and~~ shifts ~~to restore feasibility~~ to have correct number of shifts for each schedule

Step 29:

Schedule/unschedule breaks to ~~restore feasibility~~ have correct number of breaks for each shift

Step 30:

Compute the agent shortages and excesses in each period and skill type ~~using the rounded values of the agent allocation variables G~~

Step 31:

~~Reallocate agents and update~~ Update agent allocation variables G to ~~reduce shortages.~~ make total allocated in a period for a skill group equal to agents available. Update agent shortages and excesses

Step 36:

Store the solution if it has fewer ~~infeasibilities~~ agent shortages than the best known solution. Return to B&C algorithm

Step 43:

Return to B&C algorithm with the new best feasible solution

Attachment: Replacement Sheets

REMARKS

In response to the Office Action dated 30 April 2009, a telephone interview was conducted on 12 May 2009 involving a discussion of the following items. The inventor has agreed to amend claims 1-7, cancel claim 8, and withdraw claims 9-20 to meet the requirements listed in Claim Objections, Rejections under U.S.C. 112, and Rejections under U.S.C. 101.

In response to the Office Action dated 30 April 2009, a second telephone interview was conducted on 2 July 2009 involving a discussion of the following items. The inventor proposed and agreed to the revised versions of amend claims 1-7, canceled claim 8, and withdrawn claims 9-20 to meet the requirements listed in Claim Objections, Rejections under U.S.C. 112, and Rejections under U.S.C. 101.

List of Amendments

In the specifications, a number of paragraphs, lines, objective functions, and constraints have been amended to correct minor editorial issues. A new paragraph is added to page 15 to clarify the flat text notation used when a variable or set with subscripts is itself expressed as a subscript.

Another new paragraph is added to page 19 to explain the terms well known in the art such as "model', "formulation", "decision variables", "constraints", etc.

I certify that the modifications to specifications are not introducing any new matter.

The following amendments are made to the specifications, claims, FIG 4., and abstract.

Claim 8 was non-existent in the original application filed on July 7, 2003. This claim has been cancelled.

FIG. 4. is amended to renumber the parts of the flowchart on separate sheets as FIG. 4A., FIG. 4B., and FIG. 4C.

In amended FIG. 4, thirteen steps have been amended to correct minor wording issues.

In the abstract, a number of lines have been amended to correct minor editorial issues.

Per the Office Action of March 18, 2008, Claims 1-7 remain in this application, Claim 8 has been cancelled, and claims 9-20 have been withdrawn.

In view of the examiner's earlier restriction requirement, applicant retains the right to present claims 9-20 in a divisional application.

Requirement for Information under 37 C.F.R. 1.105

Copies of the documents referred to below are provided as attachments to this response to the Office Action of 30 April 2009.

Dantzig (1954): Dantzig, G. B., "A Comment on Eddie's "Traffic Delays at Toll Booths," *Operations Research*, vol. 2, 339-341, 1954.

Gaballa et al. (1979): Gaballa, A. and W. Payne, "Telephone Sales Manpower Planning at Qanta," *Interfaces*, vol. 9, No. 3, 1-9, 1979.

Aykin (1996): Aykin, T., "Optimal Shift Scheduling with Multiple Break Windows," *Management Science*, vol. 42, No. 4, 591-602, 1996.

Aykin (1998): Aykin, T., "A Composite Branch and Cut Algorithm for Optimal Shift Scheduling with Multiple Breaks and Break Windows," *Journal of the Operational Research Society*, vol. 49, 603-615, 1998.

Aykin (2000): Aykin, T., "A Comparative Evaluation of Modeling Approaches to the Labor Shift Scheduling Problem," *European Journal of Operational Research*, vol. 125, 381-397, 2000.

Bechtold et al. (1990): Bechtold, S. E. and L. W. Jacobs, "Implicit Modeling of Flexible Break Assignments in Optimal Shift Scheduling," *Management Science*, vol. 36, 1339-1351, 1990.

Bailey (1985): Bailey, J., "Integrated Days Off and Shift Personnel Scheduling," *Computers and Industrial Engineering*, vol. 9, 395-404, 1985.

Jarrah et al. (1994): Jarrah, A., J. Bard, and A. H. deSilva, "Solving Large-scale Tour Scheduling Problems," *Management Science*, vol. 40, 1124-1144, 1994.

Atlason et al. (2004), Atlason, J., M. A. Epelman, and S. Henderson, "Call Center Staffing with Simulation and Cutting Plane Methods," *Annals of Operations Research*, vol. 127, 333-358, 2004.

Atlason et al. (2008), Atlason, J., M. A. Epelman, and S. Henderson, "Optimizing Call Center Staffing Using Simulation and Analytic Center Cutting-Plane Methods," *Management Science*, vol. 54, 295-309, 2008.

Cezik et al. (2008): Cezik, M. T. and P. L'Ecuyer, "Staffing Multiskill Call Centers via near Programming and Simulation," *Management Science*, vol. 54, 310-323, 2008.

Avramidis et al. (2009): Avramidis, A., M. Gendreau, P. L'Ecuyer, and O. Pisacane, "Optimizing Daily Agent Scheduling in a Multiskill Call Center," *European Journal of Operational Research*, 2009.

A mathematical formulation of the workforce scheduling problem as a set covering model, an Integer Linear Programming model, was first developed by Dantzig (1954). Since then a number of extensions and heuristic methods have been develop in the Operations Research literature. Workforce scheduling problems studied in this area in the past fall into three categories: shift scheduling involving schedules for only one day, days off scheduling concerned with the work and off days but not the details of daily work schedule, and tour scheduling involving scheduling for more than one day (typically for a week) and involving the determination of both daily shift schedules, and work and off days.

The set covering model is applicable to days off, shift, and tour scheduling problems, and requires all possible combinations of shift, break, and work and off day combinations be enumerated. Each combination is then represented by an integer decision variable in the set covering model. The model was proposed by Dantzig (1954) for a non-skills based environment. Due to the large number of variables, the set covering model remained, to the best of the inventor's knowledge, a teaching tool that was very rarely solved in practice. The set covering model and other related research have been discussed in Aykin (1996).

Gaballa et al. (1979) considered a non-skills based shift scheduling problem with less than 24-hour operations in which each agent is given one lunch break during the shift. They also reported a separate linear programming model for weekly rostering. They introduced a lunch break variable for each shift to model break placement implicitly (i.e. without having to enumerate all shift and break start time combinations as in the set covering model of Dantzig). This approach, however, results in more decision variables and constraints in the case they considered than the set covering model, making the problem more difficult to solve. Therefore, it was not pursued further.

Aykin (1996) considered the shift scheduling problem with multiple (lunch and relief) breaks and showed that, in the more general cases, the implicit break variables approach results in significant reduction in the number of decision variables with respect to the equivalent set covering formulation. Aykin (1996) also illustrated the importance of scheduling all breaks (both lunch and all relief breaks) on the number of employees needed to meet the agent requirements.

Aykin (1996) also discusses other significant studies on the shift scheduling problem in its introduction section (pp. 591-593). Aykin (1998) developed a modified branch and cut algorithm by generating cuts (new constraints) and applying a local rounding and search heuristic at each node. The method was applied to the model of Aykin (1996). Aykin (2000) extended the implicit modeling approach developed by

Bechtold et al. (1990) for one break type per shift to multiple breaks case, and then compared the computational effort needed with that of Aykin (1996). Work described in these documents remained limited to the shift scheduling problem (i.e. only for one day) in a non-skills based environment.

The tour scheduling problem involving shift and break scheduling for multiple days, and work and non-work day scheduling in a non-skills based environment have been studied by a number of researchers including Dantzig (1954), Bailey (1985), Jarrah et al. (1994),. Baker (1985) considered only small illustrative cases. He did not consider problems of the size found in call centers, did not include break scheduling and a solution algorithm other than the use of a commercial solver with the model he developed.

Jarrah et al., (1994) combined the approach presented by Bechtold et al. (1990) with Dantzig (1954) with only one break being considered for each shift.

Recently, Atlason et al. (2004, and 2008) developed a simulation based method for staffing and scheduling in call centers. These studies again considered the set covering model for shift scheduling in non-skills based environments.

The shift and tour scheduling problems in a skills based scheduling environment have recently been considered by Cezik et al. (2008) and Avramidis et al. (2009). Both papers considered the set covering model for agent tour scheduling without break scheduling.

The present invention departs from the prior art in a number of ways. Specifically, it, among many other extensions discussed in the patent document, i) combines the implicit break modeling approach with the tour scheduling problem to reduce the number of decision variables needed to a fraction of that of the set covering model, ii) provides a Mixed Integer Programming Model (MILP) for skills based scheduling environment of which non-skills based scheduling is a special case, iii) allows for varying daily shift lengths, iv) allows for any number of daily breaks, break durations and break windows, v) allows for consistent (identical) and variable daily shift start times in a schedule, vi) includes penalties for agent shortages, vii) allows for limits on agent shortages and excess in various certain planning periods, and viii) provides a rounding algorithm coupled with the well known branch and bound algorithm for obtaining terminal solutions to the problem.

Applicant respectfully requests that a Notice of Allowance be issued in this case.

Sincerely yours,

Turgut Aykin, Ph.D.
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